# Institute of Mathematical Machines

# Mobile 3D Mapping With Tegra K1



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# Mobile 3D mapping

- Mobile robotic platform
- Rotating laser scanner
- 3D data in stop-scan fashion
- Processing using CUDA on robot

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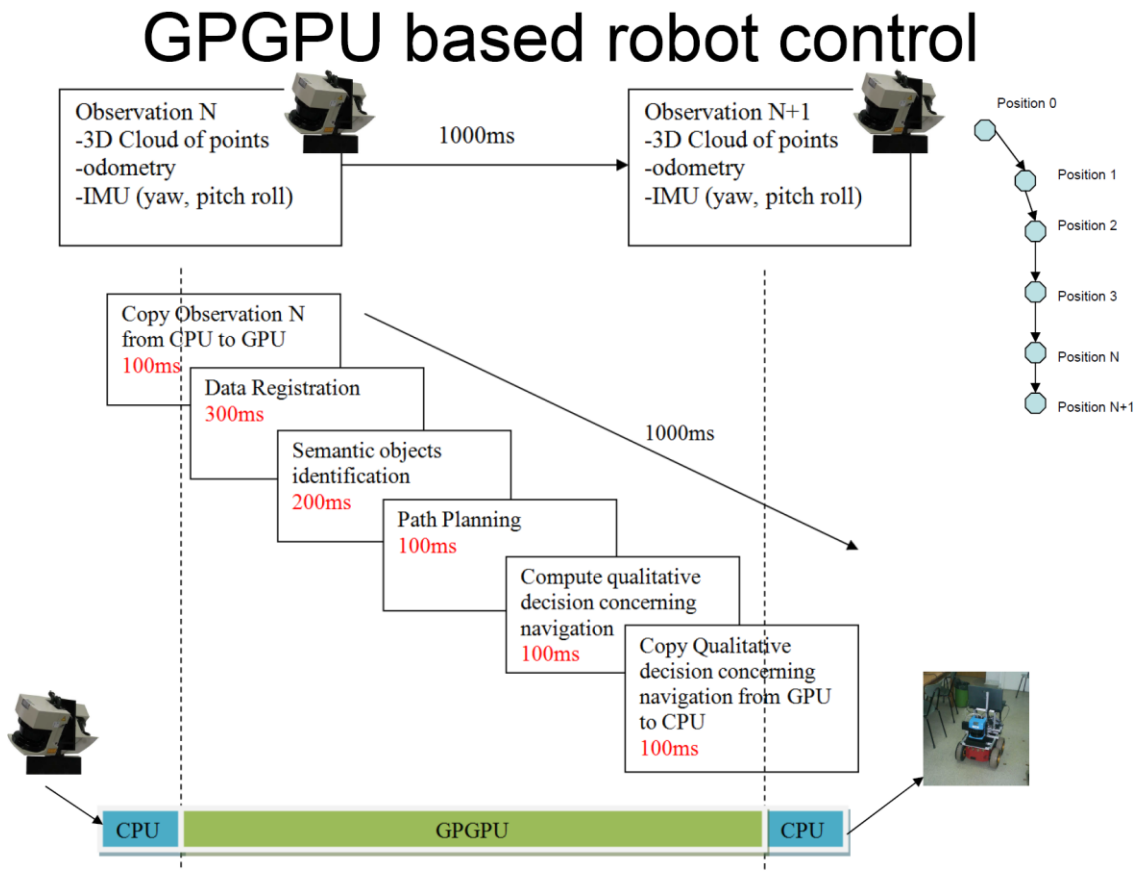
# CUDA in 3D mapping

Janusz Będkowski – GTC 2012

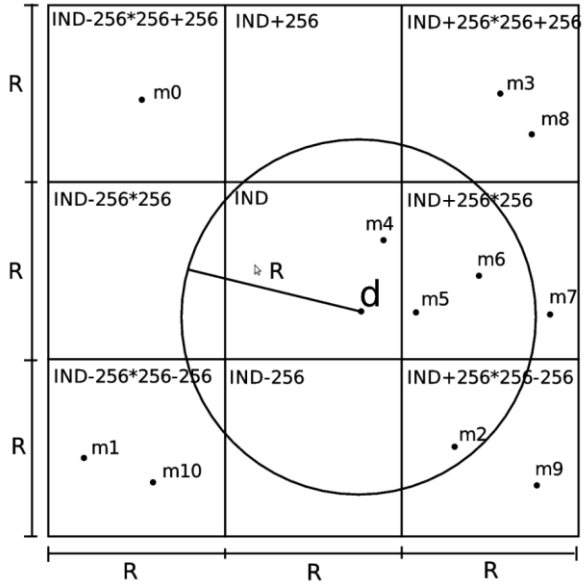


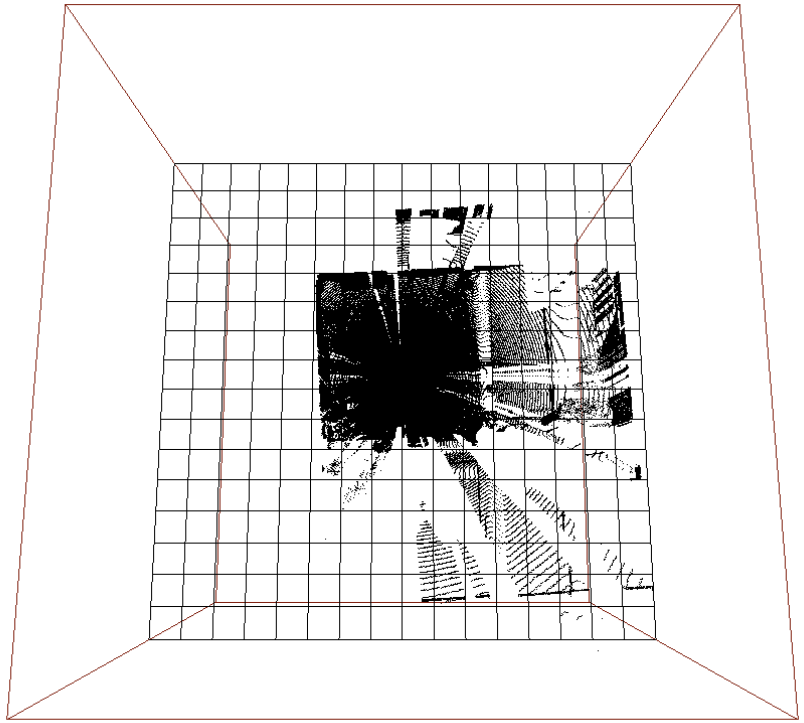

Now with Jetson TK1

- The observations from robot are in the GPU memory immediately!
- More data from the new sensors

# CUDA in 3D mapping

- Regular Grid Decomposition
- Cube (-1, -1, -1) to (1, 1, 1)
- Partitioned into $2^n$ x $2^n$ x $2^n$ cubes (n=4, 5, …, 9)
- Scale the pointcloud



Będkowski Janusz, Andrzej Masłowski, Geert De Cubber. "Real time 3D localization and mapping for USAR robotic application." *Industrial Robot: An International Journal* 39.5 (2012): 464-474.

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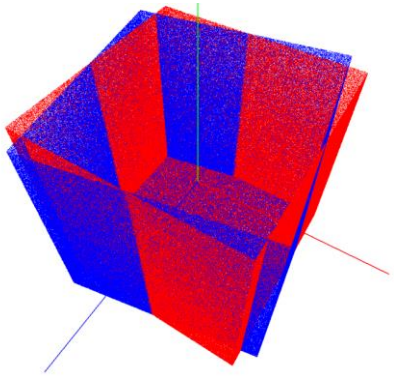
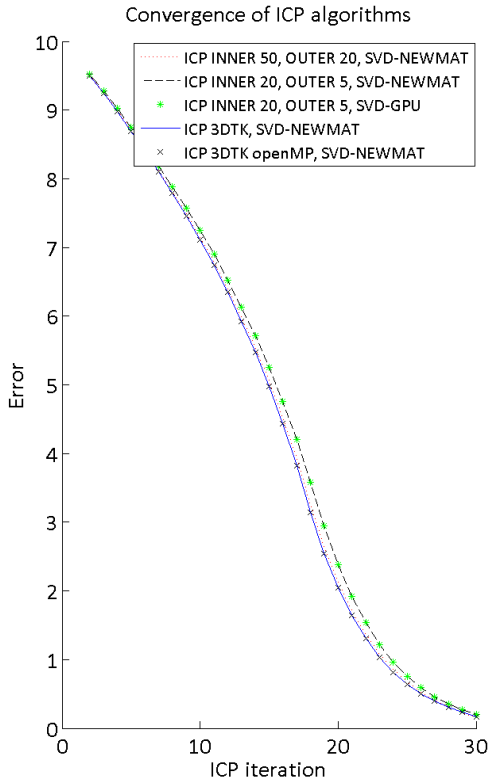
# CUDA in 3D mapping

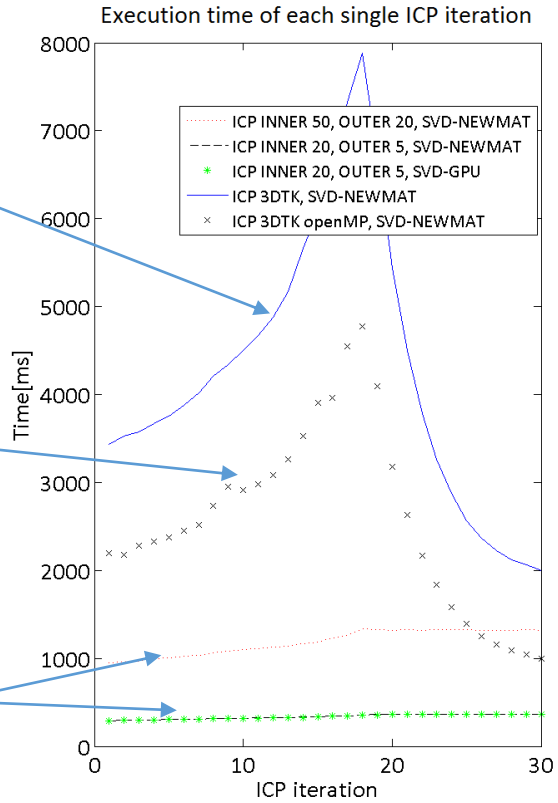


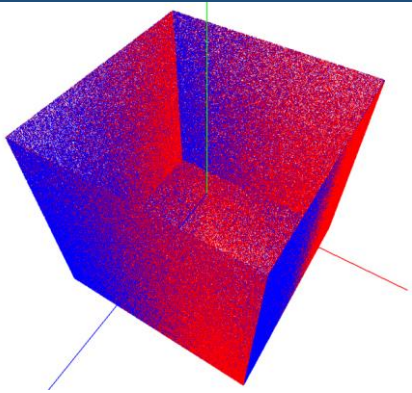



CPU

CPU OpenMP

CUDA



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Będkowski Janusz, Karol Majek, and Andreas Nüchter. "General purpose computing on graphics processing units for robotic applications." *Journal of Software Engineering for Robotics* 4.1 (2013): 23-33.

# 3D mapping with Jetson TK1

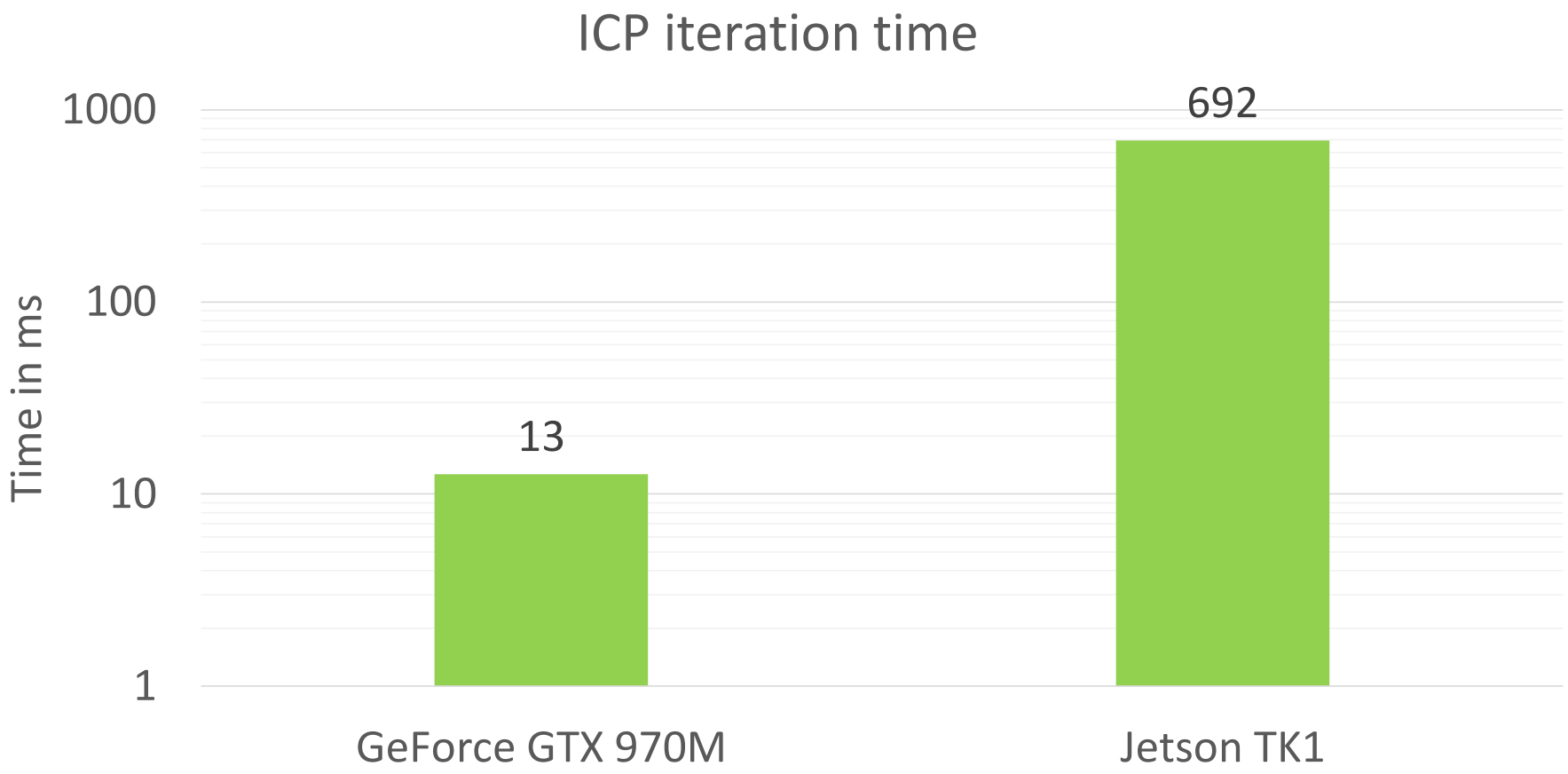
## The hardware

| | Laptop GTX 970m | Jetson TK1 |
|---|---|---|
| CUDA cores | 1280 | 192 |
| Base clock (MHz) | 924 + boost | 852 |
| Number of multiprocessors | 10 | 1 |
| Architecture (Compute Capability) | Maxwell (5.2) | Kepler (3.2) |
| Total global memory (MB) | 3072 | 1746 |
| Memory bus | 192-bit | 64-bit |
| CPU | Intel Core i7-4710HQ 2.5GHz | 4-Plus-1 quad-core ARM Cortex A15 CPU |

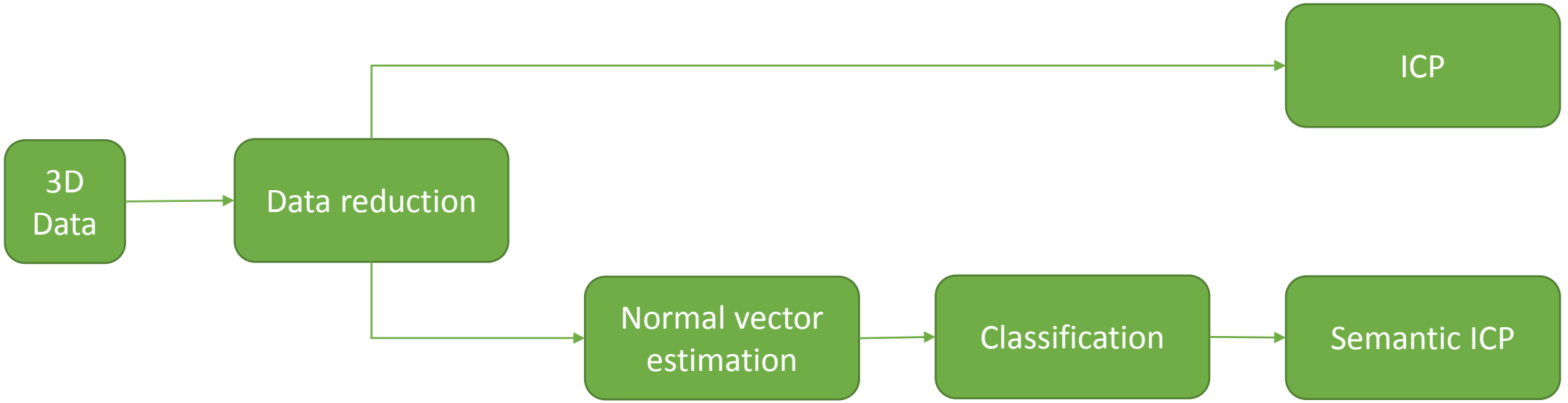

# 3D mapping with Jetson TK1

Approximately
50 000 points

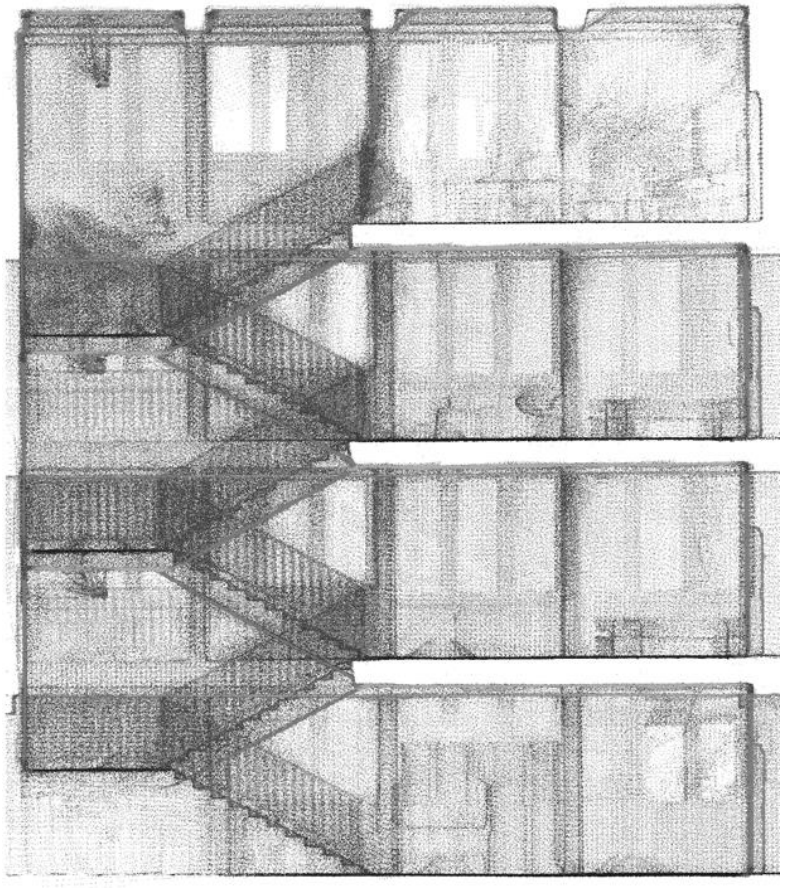
64 x 64 x 64 grid



# 3D mapping

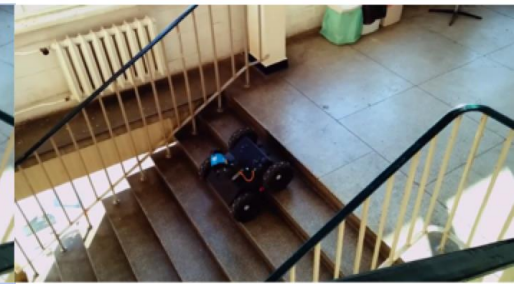

3D Data
Data reduction
ICP
Normal vector estimation
Classification
Semantic ICP

# 3D Data



53 scans
Odometry and IMU
DrRobot Jaguar 4x4 platform
Mandala 3D rotating laser unit*

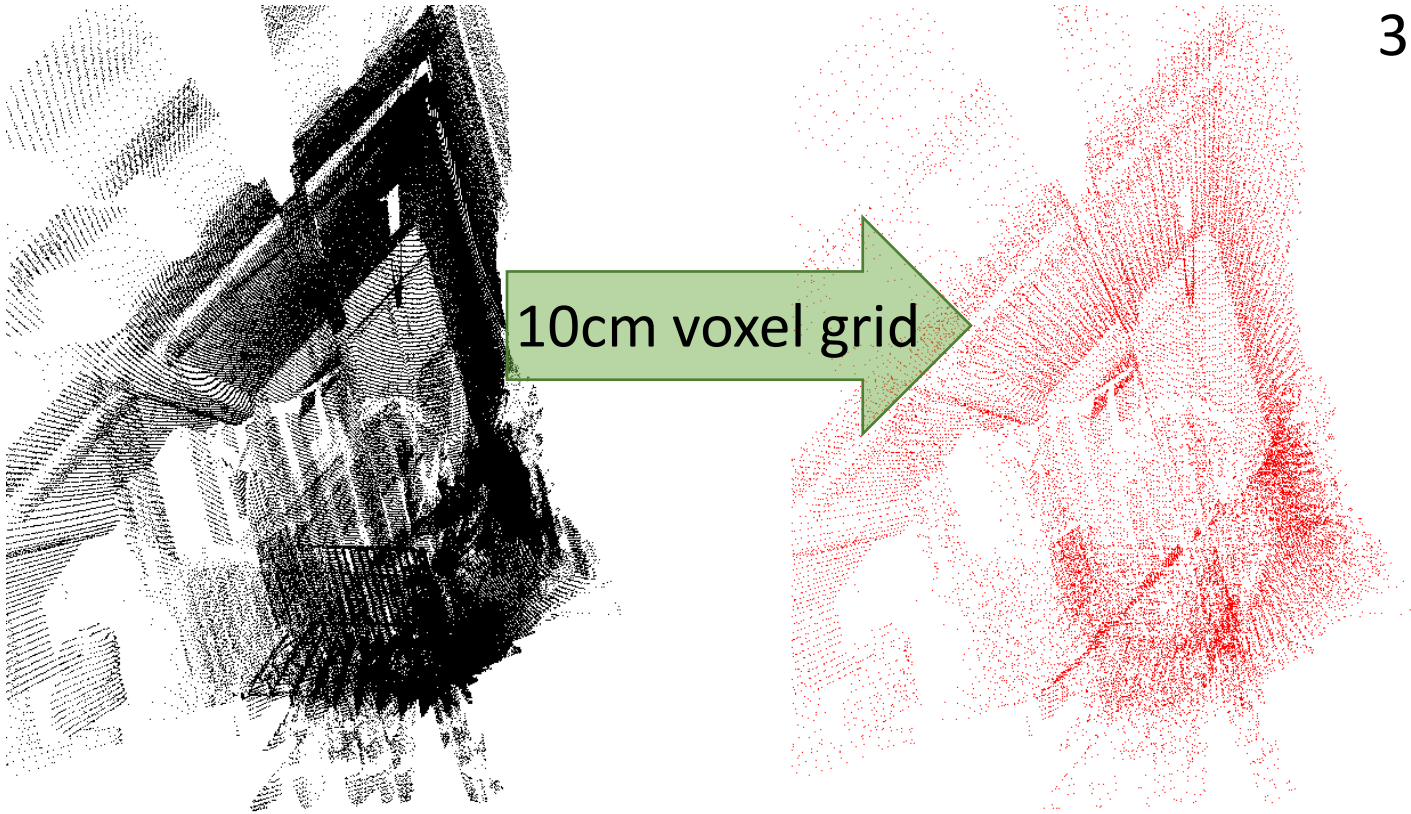
*mandalarobotics.com



The 3D datasets: lider.zms.imm.org.pl/

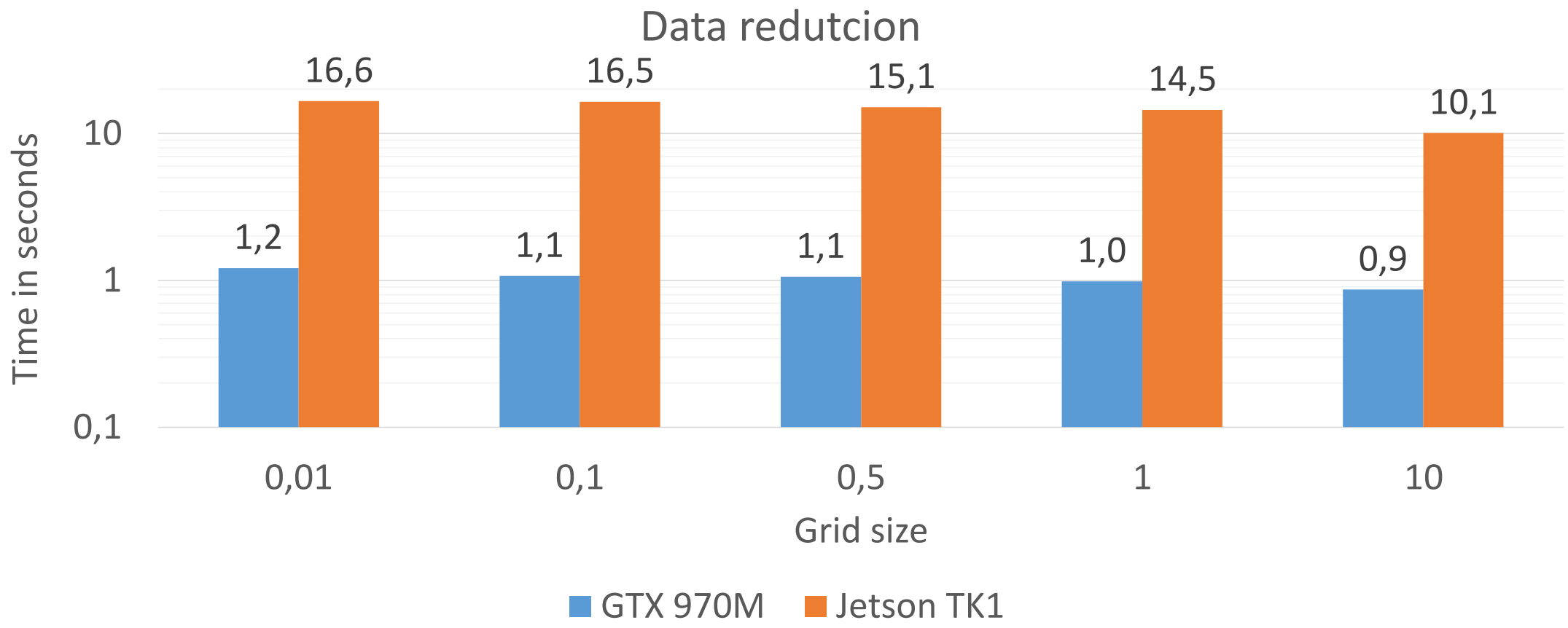
# Data reduction

506 064 points



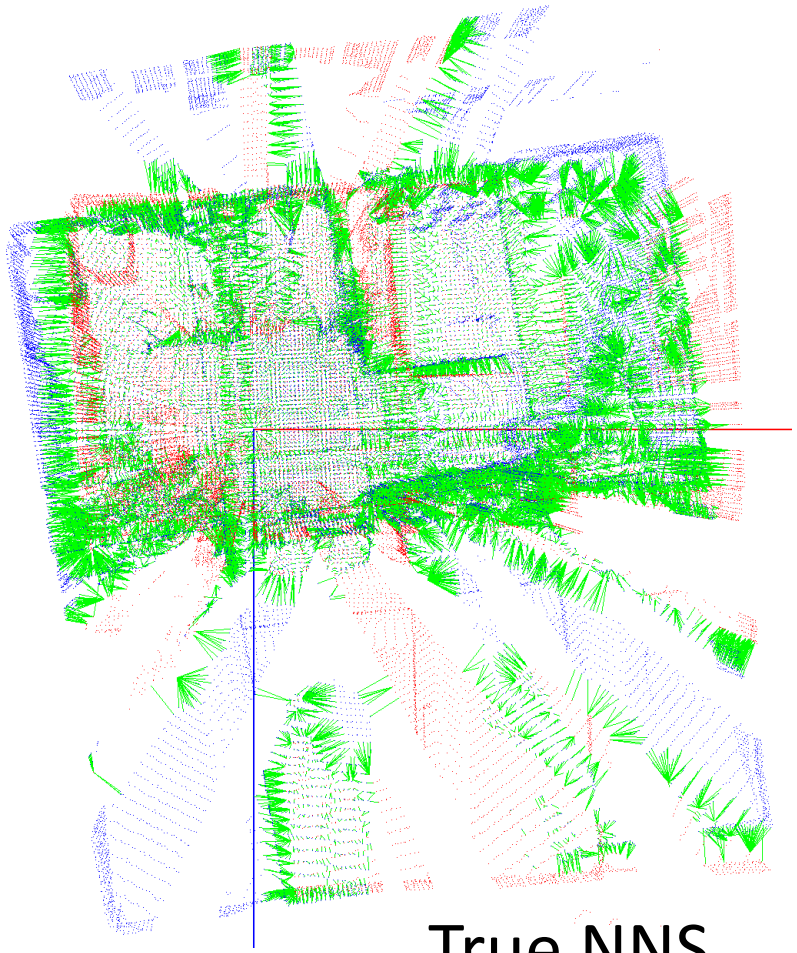

33 530 points


# Data reduction

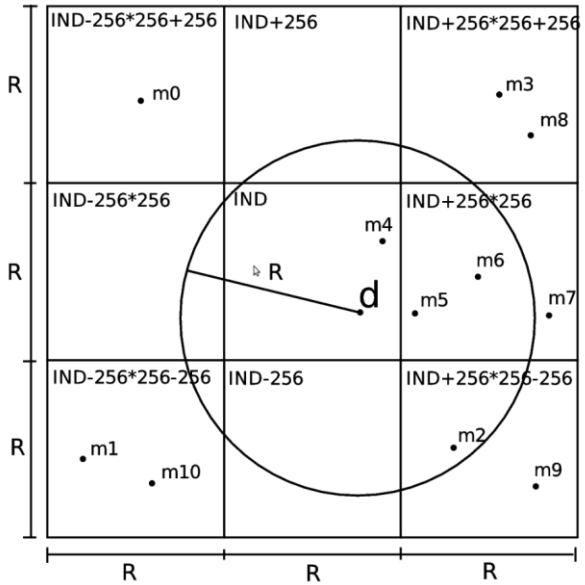


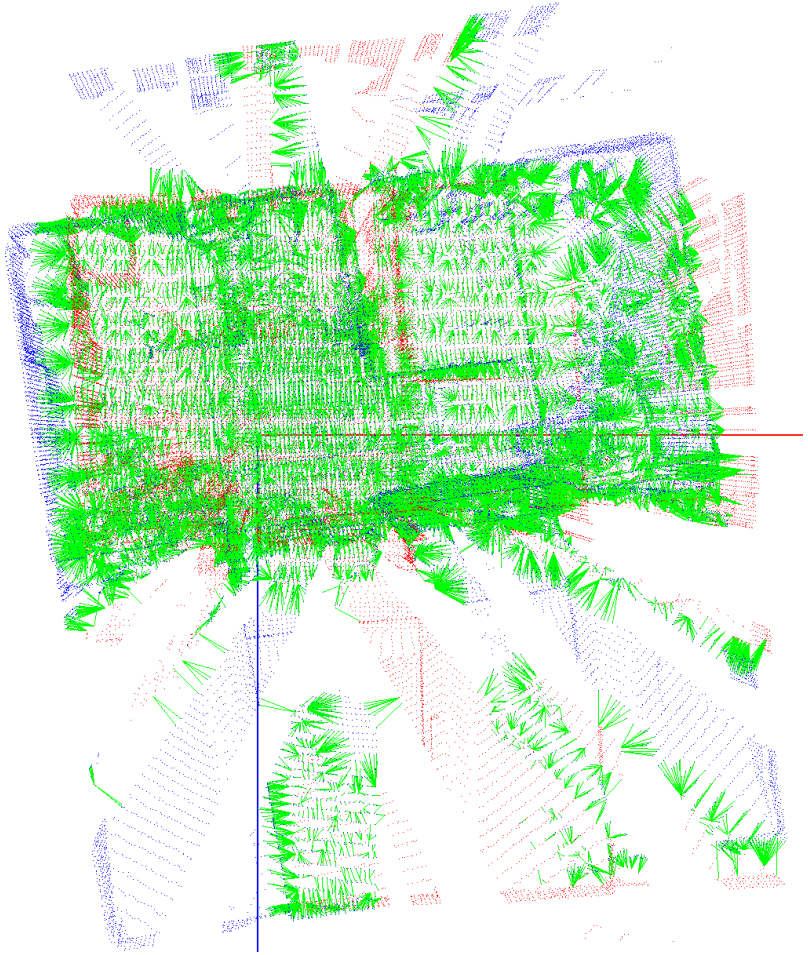

Input: 2 000 000 points

# ICP



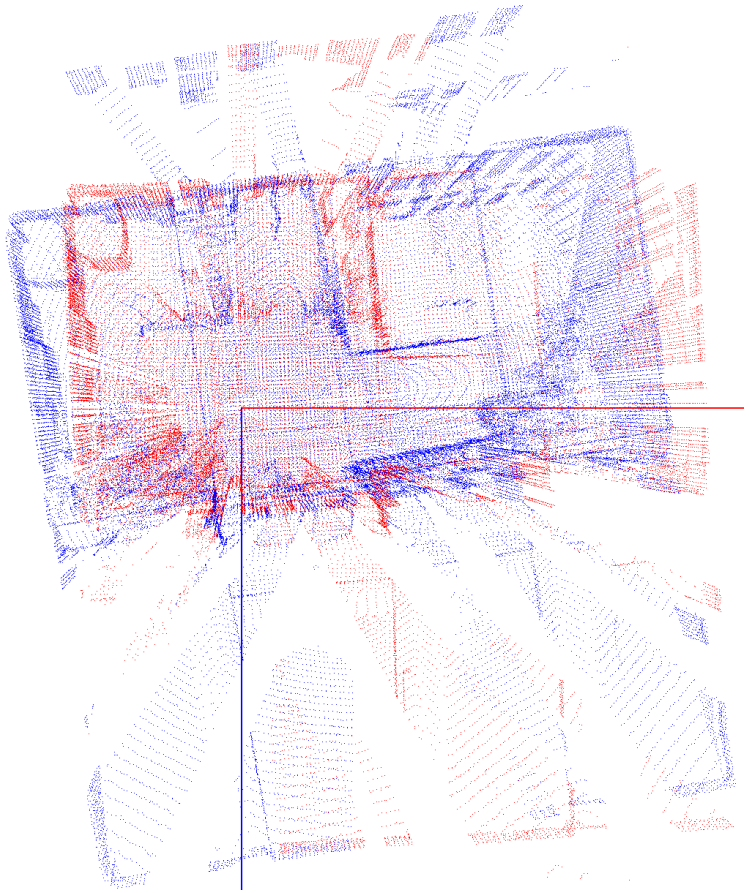
True NNS



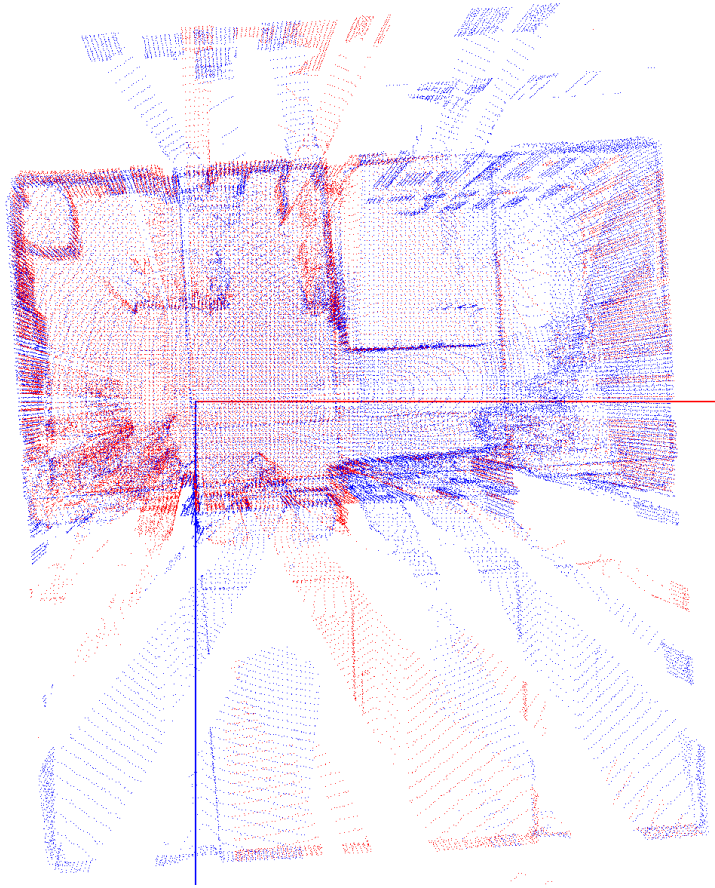



Approximate NNS

# ICP



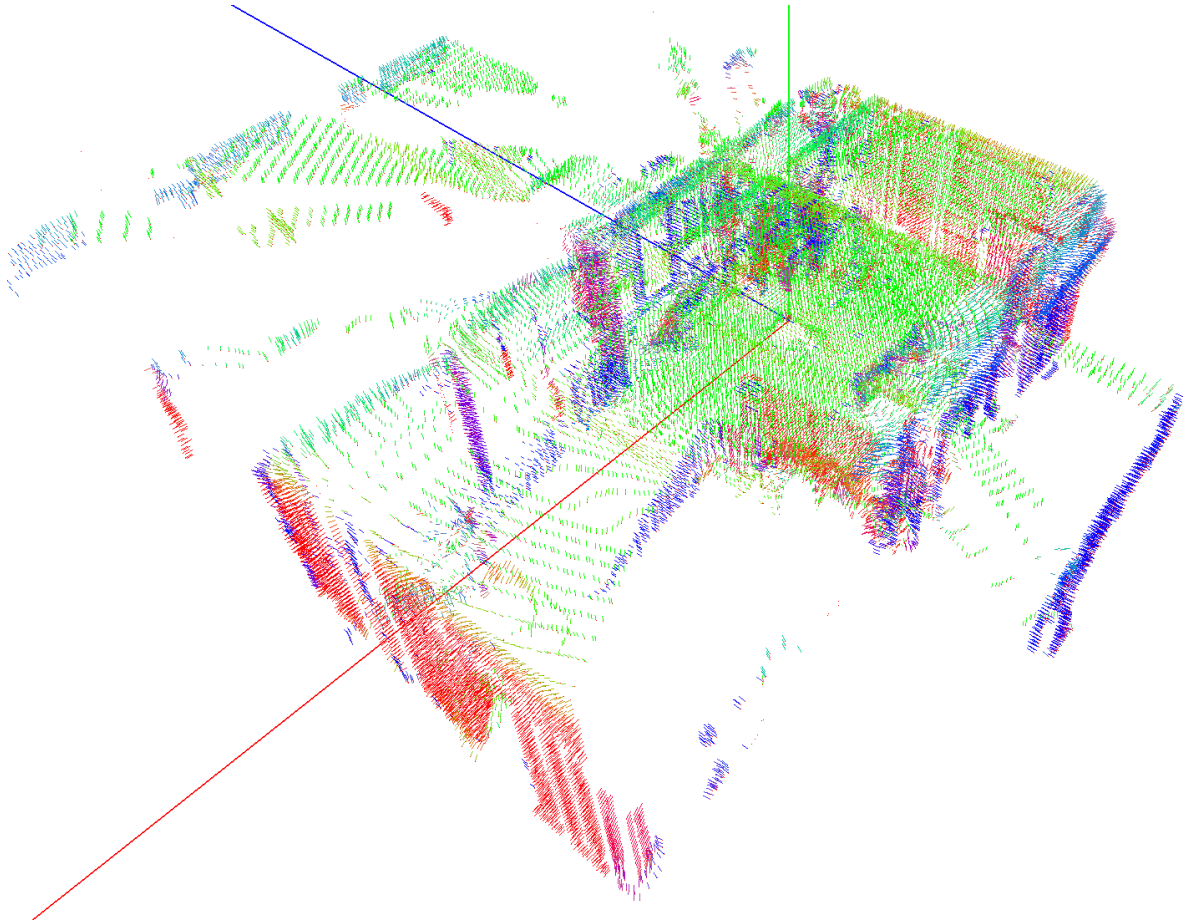
After 20
ICP iterations



# Normal vector estimation

Steps:

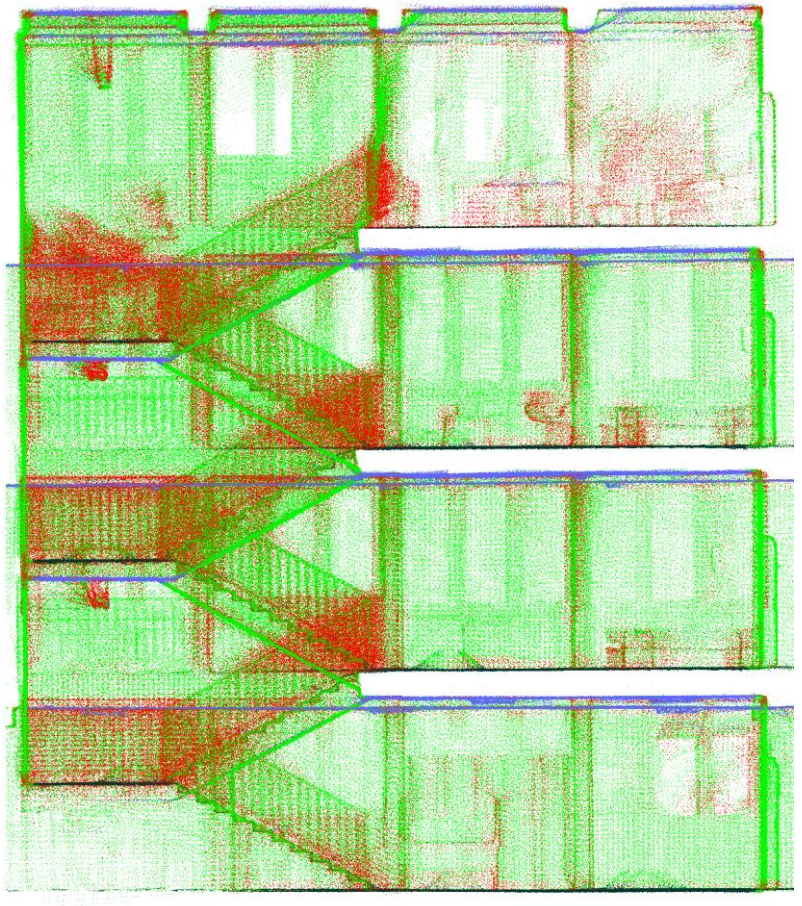
1. NNS
2. Covariance matrix from NN
3. Principal Component Analysis (PCA) using Singular Value Decomposition(SVD)
4. Orientation towards the viewpoint



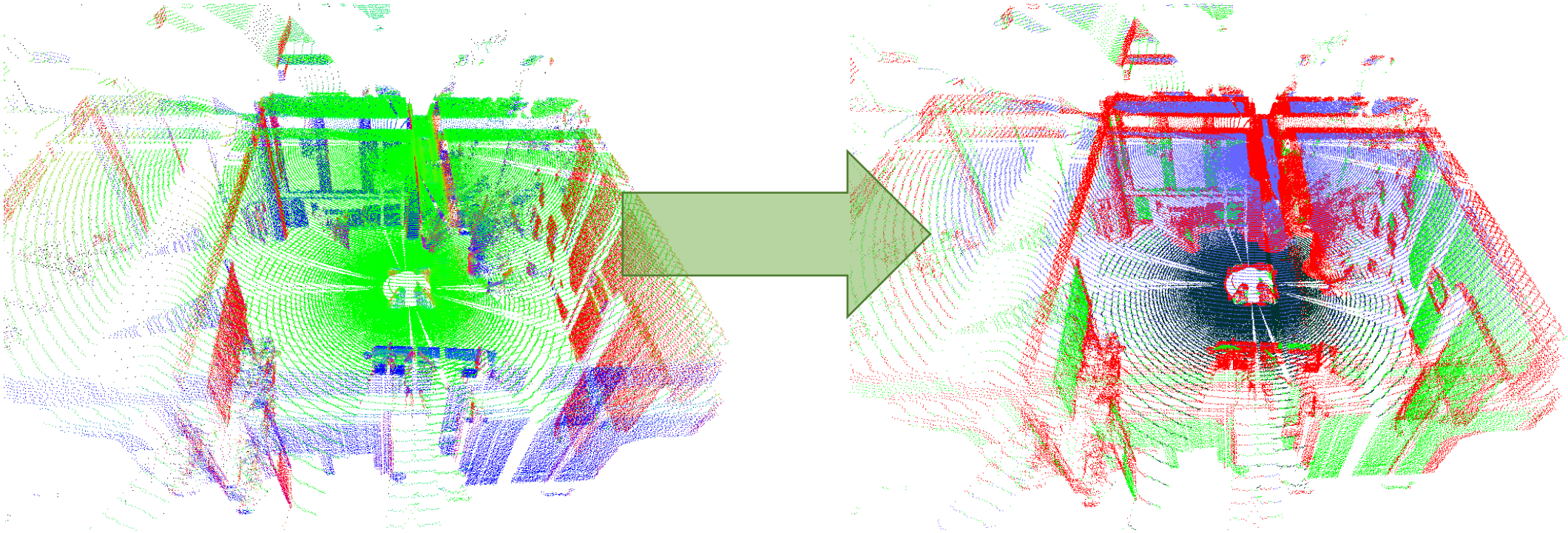
# Classification

Semantics by point labeling:

- Wall (green) – plane
- Floor (blue) – plane under robot
- Ceiling (black) – plane above robot
- Other (red)



# Classification



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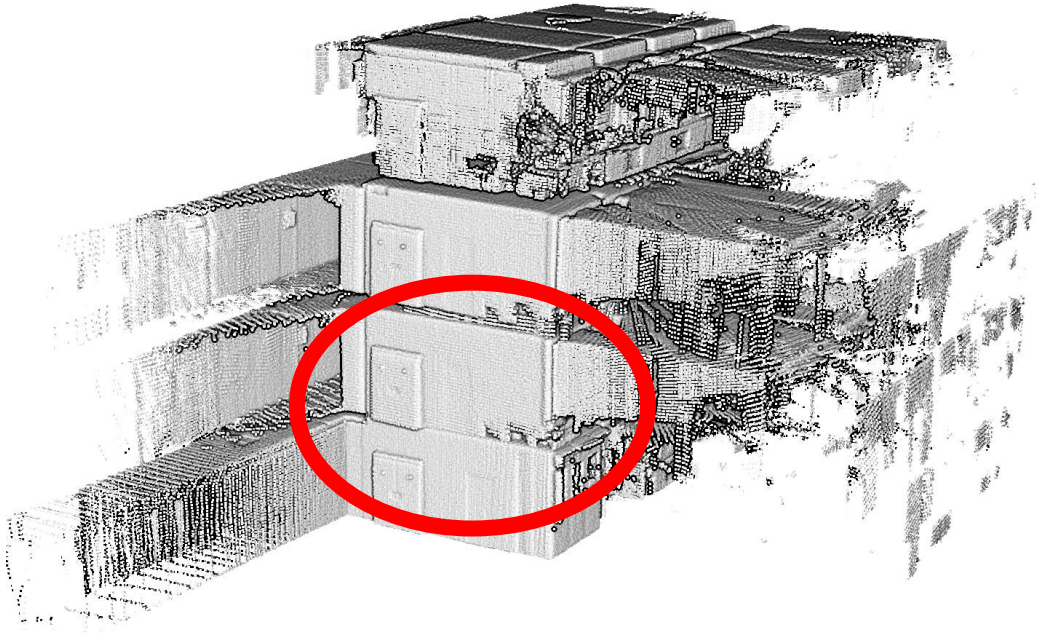
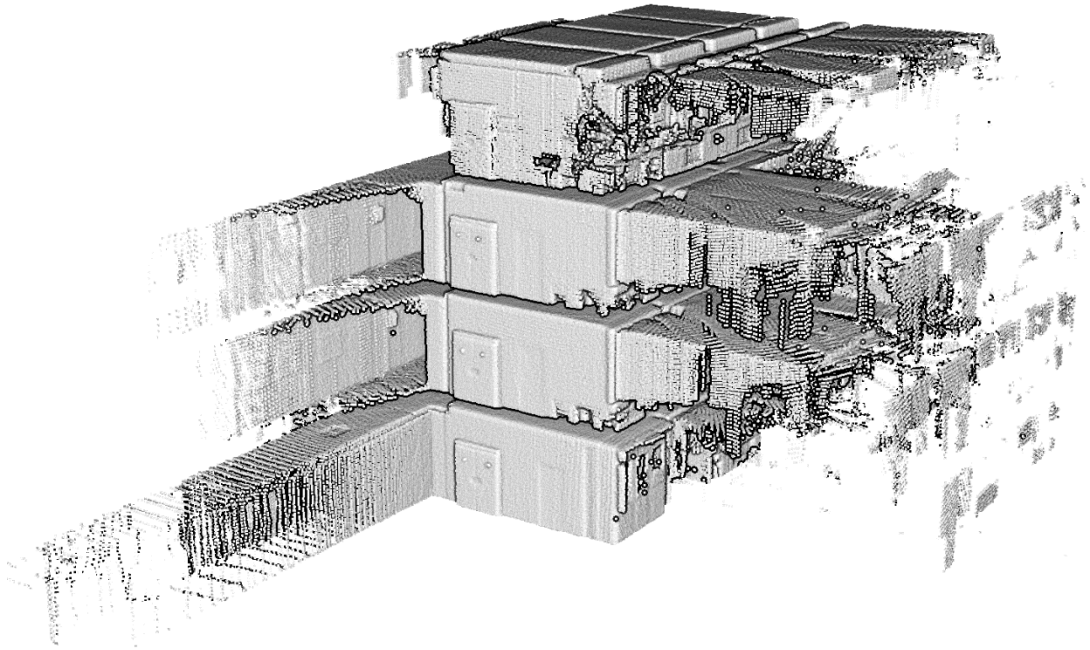
# Semantic ICP

## ICP



## Semantic ICP



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# Conclusions

Problems:

- TK1 memory is limited to approx 1.7 GB
- Low performance compared to modern laptop
- Aproximate NNS decreases the final accuracy

Solutions:

- Small datasets – data reduction
- Use of aproximate NNS instead of true NNS
- More iterations of ICP or use of the semantic ICP

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# Acknowledgement

This work is done with the support of NCBiR (Polish National Center for Research and Development) project:

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Nr: LIDER/036/659/L-4/12/NCBR/2013


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# Thank you for your attention!

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